

Cognitive Engineering Cognitive Science Applied to Human Factors

Covers cognitive theory from an applied perspective to understand and predict the interactions among human cognition, artifact (i.e., tools), and task. Cognitive task analysis (CTA) techniques will be taught and used throughout the course. The CTAs covered might include Cognitive Walkthru, Keystroke Level Modeling, Activity Networks, in general, and various members of the GOMS (Goals, Operators, Methods, and Selection Rule) family, in particular. In addition, computational cognitive models will be introduced and used to illustrate the expressive and predictive power of computational modeling. (Note that computational modeling will not be taught in this course.) Thruout the course students will be required to read and discuss original research papers.

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Topics covered may include

- **Visual search and visual attention**
- **Cognitive Skill and Its Acquisition**
- **Hard Constraints on Interactive Behavior**
- **Human Error**
- **Soft Constraints on Interactive Behavior**
- **Soft Contraints on Judgment and Decision-Making Behavior**
- **Experts & Expertise**

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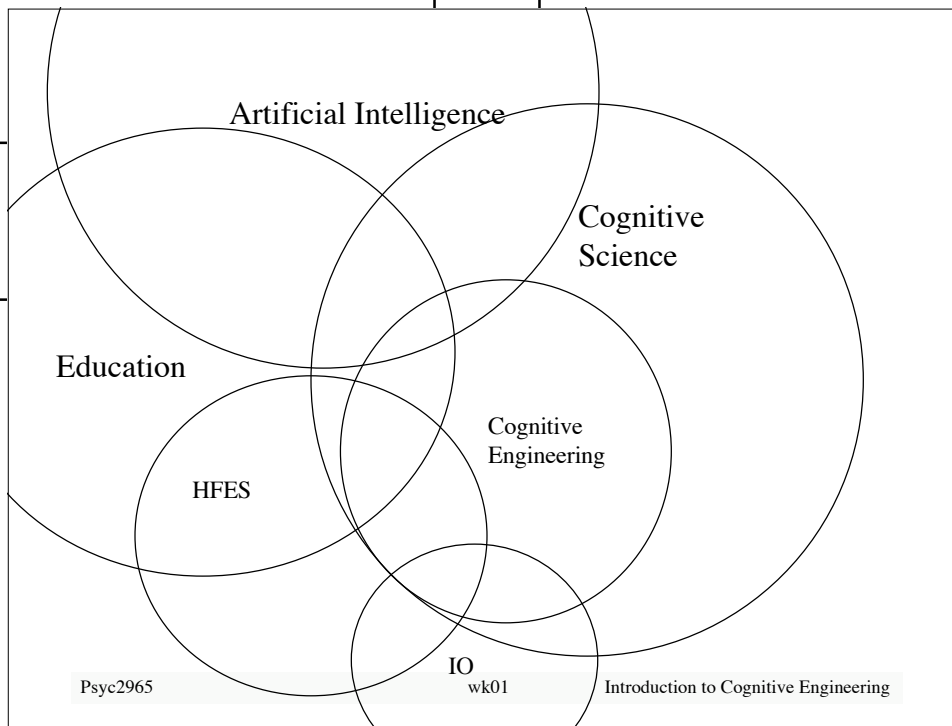
Techniques covered may include

- **Use of simulated task environments in research**
- **Use of eye movement technology**
- **Analysis of action log files**

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How does Cognitive Engineering Differ from Human Factors?

- Designing machines that accommodate the limits of the human user is a major concern of the field of human factors.
- The field of human factors is broader than this course, and broader than cognitive engineering. Both the course and the program concentrate on designing systems that accommodate the information-processing capabilities of the human mind.

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Human Factors

- Goal of Human Factors, to apply knowledge in designing systems that work, accommodating the limits of human performance and exploiting the advantages of the human operator in the process.

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Cognitive Engineering

- Is notable for its
 - Solid theoretical basis and close relation to theoretical cognitive science
 - Indeed -- most people who do cognitive engineering research also do basic cognitive research
 - (Though it is not true that most people who do cognitive engineering also do research.)

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Theoretical Cognitive Science

- Unlike cognitive engineering, the Goals of Theoretical Cognitive Science are
 - to uncover laws of behavior through empirical study and cognitive modeling
 - It is NOT a requirement that cognitive science generate immediately useful knowledge

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Human Factors, Theoretical Cognitive Science, and Cognitive Engineering

- Cognitive Engineering has its own unique goals derived from the intersection of these two: Aim of applied cognition is not simply to compare two possible designs for a piece of equipment (role of HF), but to specify the capacities and limitations of the human from which the choice of a better design should be directly deducible

Adapted from Wickens, 1992

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Research Credos

- “There is nothing so useful as a good theory.”
Lewin, K. (1951). *Field theory in social science*. New York: Harper Row.
- “Nothing drives basic science better than a good applied problem.” Newell, A., & Card, S. K. (1985). The prospects for psychological science in human-computer interaction. *Human-Computer Interaction*, 1(3), 209-242.
 - “The reverse side of the coin is that this practical pressure of technology can also be of benefit to psychological science itself by providing a sustained, concrete set of problems to solve with visibly measurable results.”

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¿Applied Cognition?

- Subtitle of course is: Cognitive Science Applied to Human Factors
- Begs the question of how does cognitive science inform human factors issue?

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Simon's Ant



“A person attempts to achieve his goals by doing those things the task itself requires to be done. Much of the complexity of human behavior derives not from the complexity of the human himself (he is simply trying to achieve his goals), but from the complexity of the task environment in which the goal-seeking takes place” Card, Moran, & Newell, 1983, p. 86.

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The fundamental principle of task analysis

- Rationality Principle.

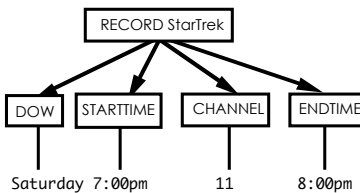
A person acts so as to attain his/her goals through rational action, given the structure of the task and the inputs of information, and bounded by limitations on his knowledge and processing ability:

Goals + Task + Operators + Inputs + Knowledge + Process-limits → **Behavior..**

Card, Moran, & Newell, 1983, p. 86.

The basic problem for goal-oriented cognition: Task-action mapping

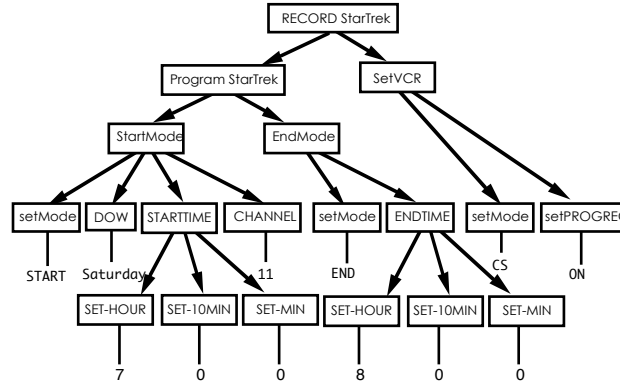
- From what we want to do:



DOW = day-of-week

Task-action mapping

- To what the artifact requires us to do:



Where "this" involves ≈30 keypresses and the setting and completing of 19 goals and subgoals

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Newell's analysis of levels: The Time Scale of Human Action

Scale (sec)	Time Units	System	Analysis	Activities/ Processes	World (theory)
1000000000	decades	Technology	Culture		Social & Organizational
100000000	years	System	Development		
10000000	months	Design	Education		
1000000	week	Task			
100000	days	Task	Traditional Task Analysis	Subtasks	Bounded Rationality
10000	hours				
1000	10 min				
100	min	Subtask	Unit Task Analysis	Procedures	Cognitive Band (symbolic)
10	10 sec	Unit task	Cognitive Task Analysis	Methods	
1	1 sec	Activities	Embodied Cognition	Microstrategies	
	1/3 sec	Embodiment Level	Production Rules	Conflict Resolution	
0.1	100 ms	Production System	Elements (DME-MA-VA)	Activation	Biological Band (subsymbolic)
0.01	10 ms	Atomic Components	Architectural		
0.001	1 ms	Parameters			

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Why do we need Cognitive Scientists?

- In Bounded Rationality band?
- Who cares about the discipline -- as long as the job gets done?
- Why not a computer scientist?
- Why not an experimental psychologist?
- What do we have to offer that other disciplines do not?

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Prospects for Psychological Science

- Newell & Card (1985)
 - Key to this class
 - Key to Cognitive Engineering as a subdiscipline
- Hard science drives out soft science

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Hard and Soft Sciences of the Interface

- Computer Science versus Cognitive Science and Human Factors
- Soft and Hard Cognitive Science
- A Cognitive Science approach to “hardening” the science of the interface

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More Problems with Current Approach

- Build two and I’ll test them
- So what?
- Cost-Benefit Tradeoffs?

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Problems of Timing and Form

- Inputs from Human Factors professionals are often not effective due to timing and form
 - Timing
 - Form

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The Vision

- Get in at the beginning
- “It’s not just my opinion!”
 - Models as the answer!
 - Answers come from the MODEL not from the MODELER

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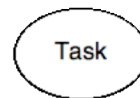
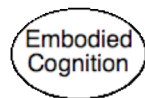
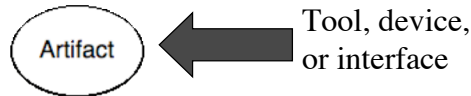
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Cognitive  Bounded Rationality

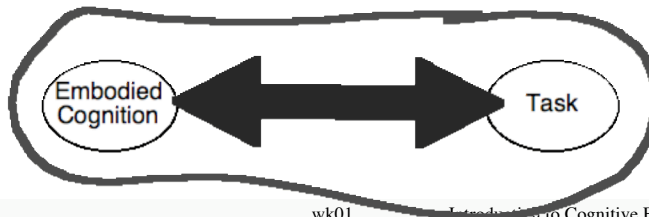
How are the cognitive and bounded rationality bands connected?

- Time duration of most activities that HF worries about lies in both the cognitive and bounded-rationality bands
- “Psychology delivers to the bounded-rationality band the model that must be used to understand what helps the user and how” (N&C, 85).
- Understanding how the task is done, requires understanding the tools available for doing the task. A cognitive task analysis, as opposed to simply a task analysis, takes into consideration the information processing tools that humans bring.

That is, the cognitive band supplies the operators and processing-limits (the ant) called for by the rationality principle. Likewise the only inputs (the beach) that matter, are those that can be operated upon at the cognitive level.

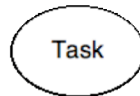
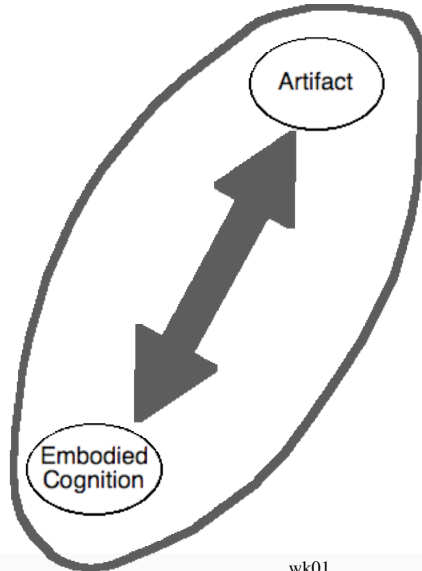


Traditional Research in Cognitive Psychology



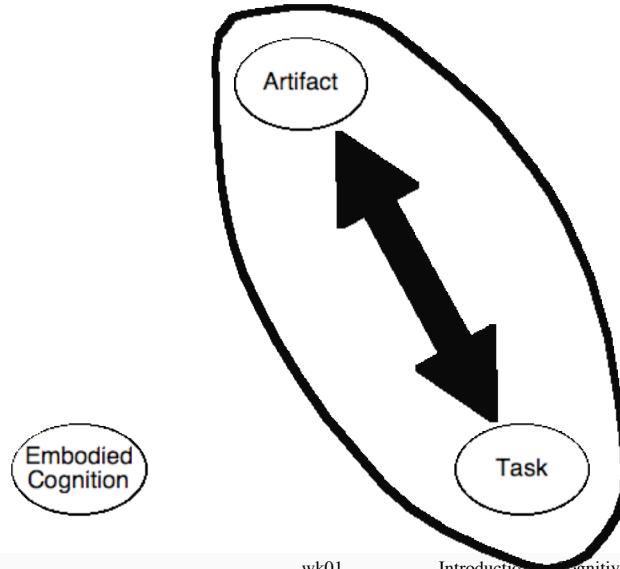
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Traditional Human Factors



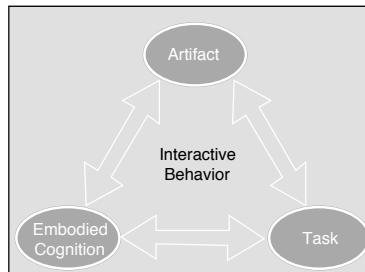
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Traditional Engineering



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The Cognitive Engineering Perspective: Taking the ETA triad seriously



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